

DOE: Let's move accelerator technologies to commercial markets

Accelerator-based technologies are used in the production and handling of everyday items, from gems to tires to weapons.

Six US Department of Energy national labs have been on the make of late: They want to meet you, and they want you to get to know them better, too. Representatives from the six labs have held events, attended conferences, and engaged in networking to seek out people from industry, academia, and other national labs who want to learn about and use their tools. Those efforts represent the ramping up of the Accelerator Stewardship Test Facility Pilot Program. A 28 April launch event for the pilot, held jointly by Fermilab and Argonne National Laboratory, attracted about 100 people. Since the event, says Robert Kephart, director of Fermilab's Illinois Accelerator Research Center, "we've been approached by both old friends and a few first dates" to talk about launching joint projects.

The roughly \$1 million pilot is part of the Accelerator Stewardship program, which DOE's Office of High Energy Physics (OHEP) started last year with \$10 million; it has \$10 million again for fiscal year 2015. "The notion of stewardship," says Eric Colby, who manages the program, "is that one federal agency takes guardianship of accelerator activities for the government and the nation." The activities extend beyond large accelerators to R&D that addresses potential applications.

Accelerator economies

"We have only realized over the past few years how broad the use of accelerators is," says Kephart. "Accelerators touch \$500 billion worth of products per year." Probably the best-known uses are in cancer therapy, medical isotope production, and food irradiation. But, says Kephart, "accelerators are almost the exclusive method for implanting ions in semiconductors. Cell phones, cameras, and TVs all depend on accelerators." They have security uses such as monitoring cargo for contraband. And they are used to cross-link polymers or break molecular bonds for shrink-wrapping food and other packages, reducing friction in artificial human joints, modifying the color of gems, curing rubber in radial tires, and

treating coal-plant flue gases and wastewater.

The world population of accelerators is around 30 000, according to a report from the 2009 DOE workshop "Accelerators for America's Future." That big number, which includes electron-beam accelerators and ion implanters, came as a big surprise to many attendees, even accelerator physicists. (See the article by Robert Hamm and Marianne Hamm in PHYSICS TODAY, June 2011, page 46.)

The workshop was "eye-opening," says Michael Zisman, a physicist at Lawrence Berkeley National Laboratory (LBNL). "Accelerator science is a small fraction of the uses," he says. "In terms of industrial and medical accelerators, there are tens of thousands. As for the big ones, like the Tevatron and LHC, it's tens, not thousands."

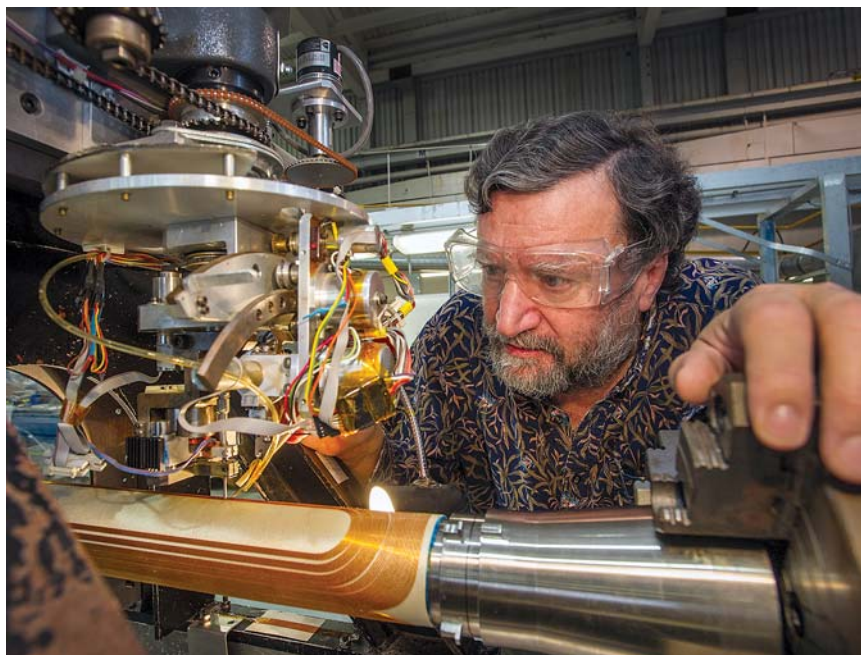
After the workshop, Congress requested that DOE set up a task force and create a 10-year plan for technology transfer from accelerator-based science to a broad range of industrial and medical uses. The potential applications

provided motivation for stewardship, says Zisman, who was detailed to DOE to help launch the program. And, he says, there was a sense that, despite being the main supporter of long-term accelerator R&D, OHEP was contributing as "an unsung hero. It was getting little or no recognition" for developments that feed into applications that benefit society and bolster US economic competitiveness.

From lab to market

The Accelerator Stewardship program has two overlapping thrusts. The new pilot program to share facilities and know-how joins the bigger and broader effort to transition accelerator technologies that have been developed for science—mostly by and for the high-energy physics, nuclear physics, and basic energy sciences divisions of DOE—to a wider user base.

"At the moment there is a 'valley of death' between the advanced accelerator know-how in the labs and what is marketable," says Colby. "There is a lot of great stuff in the labs. But it's not ready for prime time. Accelerator stewardship aims to do the translational re-



BROOKHAVEN NATIONAL LABORATORY

The direct-wind machine at Brookhaven National Laboratory creates superconducting magnets. The computer-controlled device can lay wire to an accuracy of 25 microns. A new pilot program at DOE makes such tools available to outside users.

search that will move the technology to a point where others are willing to invest and move the technology into the commercial market."

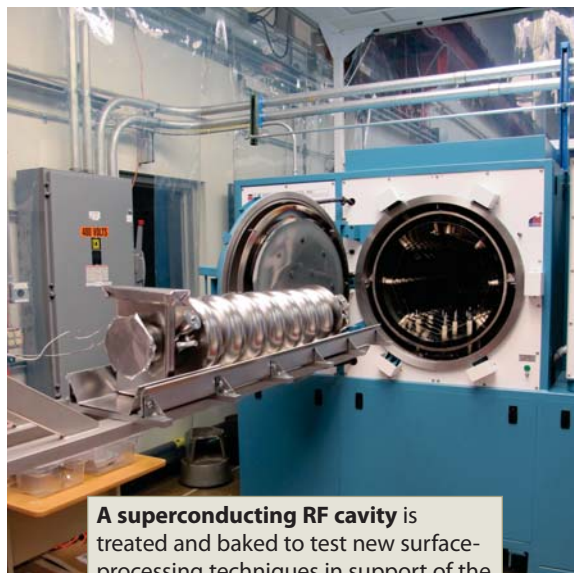
The program's flagship user resource is Brookhaven National Laboratory's (BNL's) Accelerator Test Facility (ATF), which produces electron and laser beams. The ATF was selected to receive full coverage for operations plus a \$5 million upgrade. Most user facilities award time based on scientific merit, says Colby. "We wanted to broaden that to include technical merit. We want people to be able to come in the door to test a gizmo that may not lead to scientific publication." Another reason for designating a flagship, he says, "was to be clear that the facility is available for the broader good, and not just for high-energy physics."

"The ATF has been doing stewardship since before the term was coined," says Ilan Ben-Zvi, BNL's head of accelerator R&D. "We never turned down industry, but they tended to apply to do things with a science element. We are now encouraging technology development to help discoveries move from lab to market. That is a big change for us." The ATF upgrade includes increasing the electron beam energy from 80 MeV to 160 MeV and the power of the facility's signature carbon dioxide laser from 1 TW to 100 TW. It will also enlarge the space for doing experiments.

Under the technology-transfer thrust, the stewardship program this year awarded six grants totaling about \$8 million over three years. The awards, selected from nearly 100 applications, include two for improving cancer therapies: One is to develop lightweight superconducting magnets to reduce the weight and size of gantries for ion therapy, and the other is for work on ironless superconducting cyclotrons (see PHYSICS TODAY, June 2015, page 24). The remaining four awards are to test technologies for ultrafast lasers, develop energy-recapture methods to save money on operating klystron-powered linacs, automate control of accelerators, and explore focusing techniques to increase cyclotron beam power.

Hidden equipment

"Significant resources" and years may go into "tackling challenging accelerator applications questions" for the translational portion of the stewardship program, says Colby. In contrast, he



A superconducting RF cavity is treated and baked to test new surface-processing techniques in support of the x-ray free-electron laser at SLAC. The ultraclean, high-temperature furnace is among the facilities Jefferson Lab is opening to a broad user base.

says, "the spirit of the pilot program is different. We are putting in just a bit of money, and we want a sincere answer to the question, Who wants to use this test infrastructure, and why?"

The six labs involved in the pilot program are Fermilab, Argonne, LBNL, SLAC, BNL, and Jefferson Lab. Oak Ridge National Laboratory withdrew for now because staff are too busy with the Spallation Neutron Source and other activities, and stewardship activities are not supposed to interfere with a lab's primary science mission. In the future, says Colby, the hope is to expand to more labs.

To start the pilot program, the participating labs assembled lists of equipment that could appeal to outside users. "There are more than 50 accelerator test facilities that were built in support of larger facilities but are not widely known," says Colby. Examples include test stands for superconducting RF cavities, equipment for preparing and testing surfaces, and magnet-winding platforms. "There is unique, one-of-a-kind stuff hiding in the labs. The catch is, unlike with the user facilities, there has been no funding for outside users."

The pilot is challenging, says Colby, "because it involves legal frameworks for opening facilities to outsiders. Who pays? How much? What kinds of contracts do we draw up? How do we handle intellectual property?"

Colby is hoping for quick answers. Each of the participating labs was invited by OHEP to submit two proposals jointly with an outside entity by 15 June, and the awards will be announced next

month. As of press time, James Clayton of Varian Medical Systems was talking with Fermilab scientists about collaborating on tests for high-voltage insulating gases that could replace sulfur hexafluoride as a more environmentally friendly insulator for RF power transmission from klystrons to accelerators. "The project has a finite timeline, it's not a multiyear thing," says Clayton. "It could form a template—for the nature of these collaborations and how to handle intellectual property." (Varian is also a partner in the gantry project awarded by the stewardship program.)

In any collaboration, says Clayton, "both parties have to come in being flexible. Companies and the labs have completely different mindsets." The parties need to agree about costs, timelines, and project deliverables, he says. "Both parties are trying to feel their way a bit on how to do this."

Collaborating with industry

"The labs have the ability to design and construct something that requires a large infrastructure—something no company is going to invest in," says Fermilab director Nigel Lockyer. "We want to work with companies so we are not just solving technical problems," he says. "Collaborations have to work both technically and economically."

Fermilab, for example, is looking into developing compact mobile accelerators. "There are a whole bunch of present and future applications" for such accelerators, says Kephart. If a polymerizable binder were added to the gravel, "you could drive over a freshly paved road with an accelerator to change the material properties *in situ*. An accelerator can penetrate deeply to cross-link." The asphalt would be stronger, the roads would last longer, and taxpayers would save enormously, he says.

"All of us [at the labs] have come across people from industry and academia who have said, 'We didn't know [that infrastructure] existed, and we didn't know we could access it,'" says Andrew Hutton, Jefferson Lab's associate director for accelerators. Making equipment and people available beyond the host lab "is a wonderful goal," he says. "The taxpayers pay for us to build these things for the future of our basic research, and there ought to be spin-offs. What direct use was there in going to the Moon? Nothing. But there were huge spin-offs."

Toni Feder